NCPTT 2007 GRANTS

Colloquium on the Development of Curricula in Heritage Preservation Engineering Grant #: 021722

NARRATIVE FINAL REPORT, May 2011

Principal Investigator

Jeffrey Marshall

School of Engineering, University of Vermont Votey Hall, 33 Colchester Avenue, Burlington, VT 05405 802-656-3826 Jeffrey.Marshall@uvm.edu

Co-Investigators

Mandar Dewoolkar

School of Engineering, University of Vermont Votey Hall, 33 Colchester Avenue, Burlington, VT 05405 802-656-1942 mandar@cems.uvm.edu

Douglas Porter

School of Engineering, University of Vermont Votey Hall, 33 Colchester Avenue, Burlington, VT 05405 802-656-4027 Douglas.Porter@uvm.edu

Donna Rizzo

School of Engineering, University of Vermont Votey Hall, 33 Colchester Avenue, Burlington, VT 05405 802-656-1495 drizzo@uvm.edu

Colloquium Steering Committee

Ron Anthony – Anthony & Associates, CO
Mandar DeWoolkar – School of Engineering, UVM
John Fidler – Simpson, Gumpertz & Heger, CA
David Fischetti – DCF Engineering, NC
Paulo Lourenco – School of Engineering, University of Minho, Portugal
Jeffrey Marshall, School of Engineering, UVM
Robert McCullough – Graduate Program in Historic Preservation, UVM
Douglas Porter, School of Engineering, UVM
Donna Rizzo – School of Engineering, UVM

Colloquium Moderators

Ronald Anthony (Anthony & Associates): *Timber structures*Nick Artim (Heritage Protection Group): *Disaster preparedness*John Fidler (Simpson, Gumpertz, and Heger): *Materials, testing, deterioration*

Dave Fischetti (DCF Engineering): *Treatment systems (repair and strengthening)*

Donald Friedman (Old Structures Engineering): *History of technology, engineering, codes*

Michael Henry (University of Pennsylvania): *Sustainability, efficiency,* Paolo Lourenco (Universidad de Minho, Portugal): *Masonry, earthen structures*

Rick Ortega (Hillier Architecture): *Building systems and performance,* environmental physics

Rick Ortega (Hillier Architecture): *Preservation ethics, standards, legislation*

Efrain Ovando-Shelley (Ciudad Universitaria, Mexico City, Mexico): *Geotechnical design*

Mike Shuller (Atkinson-Noland): *NDE*, sensors, diagnostics David Woodcock (Texas A&M University): Documentation, recording

TABLE OF CONTENTS

Projec	ct Narrative
	Executive Summary
	Introduction
	Methods
	Results and Discussion
	Conclusions
Ackn	owledgments
Refer	ences

PROJECT NARRATIVE

EXECUTIVE SUMMARY

The School of Engineering at the University of Vermont (UVM) has been exploring the addition of heritage preservation engineering modules to its existing curriculum. To that end the School, with the sponsorship of the National Center for Preservation Technology and Training and the Getty Conservation Institute, hosted a colloquium in June 2009 to identify curricular additions for a program focused on the engineering evaluation and remediation of heritage structures.

A two-day event that attracted approximately forty participants – academics and practicing engineers – from the U.S., Europe and Central and South America, the colloquium focused on the quantitative techniques and methodologies applied to the engineering evaluation and remediation of heritage structures, and the challenge of ensuring that students acquire the competencies necessary to address the challenges of the market.

The colloquium opened with a plenary session that included presentations on the worldwide need for heritage preservation engineering programs, the market requirements to be met by such programs, and the educational and institutional challenges likely to be associated with such programs. The plenary session was followed by a series of discussion groups working on predetermined topics. There were a total of twelve topics, each represented summarily by a position paper authored by the discussion moderator and related to development of modules that may be added to existing engineering curricula.

INTRODUCTION

Until recently, the role of engineering in historic preservation practice in the United States has not been particularly well defined. Historically, most heritage preservation efforts have been aimed at relatively small buildings that are the legacy of the colonial era and the early 19th-century, while engineering efforts have focused on the analysis and design of new buildings. This relationship is changing as focus on the recent past has brought larger and more highly engineered buildings under the purview of preservation design specialists. This trend has been accompanied by increased participation of engineers in historic preservation projects, and the development of a body of literature devoted to preservation engineering issues:

 ICOMOS has convened the International Scientific Committee on the Analysis and Restoration of Structures of Architectural Heritage (ISCARSAH), which has

developed a series of Principles defining the roles of engineers in heritage preservation.

- International EU Congresses on Construction History and the Structural Analysis
 of Historic Construction are helping to organize the effort of heritage preservation
 engineers in Europe.
- More U.S. historic preservation programs are offering engineering-oriented courses, focused on materials and structure.
- The National Center for Preservation Technology and Training is hosting a Summer Institute for Architecture and Engineering Training.
- The Association for Preservation Technology has established a Preservation Engineering Technical Committee that has resulted in the publication of more articles in the APTI Bulletin on the subject of preservation engineering, and inclusion of an engineering track in recent APTI conferences.

The application of engineering techniques to archaic buildings, materials, and structural systems present a number of unique challenges that are seldom addressed in university engineering programs. Many of these challenges are characterized by concurrent commitments to the authenticity and historic integrity of heritage structures on the one hand, and to public safety on the other. American universities have been slow to develop curricula focused on heritage education for engineering students, but as the roles of engineers in historic preservation projects become more prominent, it is vitally important that universities take the lead in teaching, research, and field projects focused on heritage preservation.

METHODS

The School of Engineering at the University of Vermont is in the process of adopting heritage preservation engineering as a new area of focus for its undergraduate and graduate programs. New curricula are likely to include heritage preservation modules to be added to existing courses, as well as new courses focused specifically on heritage preservation engineering.

In order to guide the process of curricula development, the School organized a colloquium that assembled a group of nationally prominent engineers, design professionals and conservators specialized in heritage preservation, and educators involved in similar programs overseas for the purpose of gathering input in the area of curriculum development. Areas of specialization represented by colloquium participants included:

- Historic timber buildings
- 18th and 19th-century industrial architecture
- Unreinforced masonry construction
- History of technology and codes
- Pathology of archaic materials and assemblies

- Building forensics, NDE, and documentation
- Building systems performance
- Sustainability and energy efficiency
- Preservation ethics
- Documentation and recording
- Geotechnical design
- Treatment systems
- Protection against natural disasters

The colloquium focused on modification of the existing curriculum to include heritage preservation topics, but also produced information useful for developing future courses devoted to heritage preservation. These courses will be developed and implemented progressively, in response to increased student interest and involvement. Ultimately undergraduate and graduate curricula will be developed across a broad engineering spectrum addressing a wide range of system designs through sustainability issues, structural analysis of existing construction and design of alterations, materials characterization, energy, heat and moisture transfer in buildings and components, fire safety of archaic assemblies, remote monitoring platforms, etc. Heritage preservation engineering also has the potential for incorporating several elements of the humanities, including art, architecture, and history and will create the potential for collaborations with other units on campus.

Topics to be covered by the colloquium were identified by the steering committee and included: nondestructive evaluation and sensors-based diagnostics; history of technology, engineering, and code development; preservation ethics, standards, legislation; sustainability (efficiency and environmental physics); disaster preparedness; characterization and deterioration of archaic materials; masonry, earth, and timber structures; geotechnical design; treatment strategies; building systems and performance and; documentation and recording.

The colloquium opened with a series of plenary presentations that explored the worldwide need for heritage engineering programs, the requirements to be met by such programs in local, regional and national markets, and the educational and institutional challenges likely to be associated with them. These were followed by a series of group discussion sessions organized around position papers written by the discussion moderators. Position papers addressed the development of course modules related to each of the topics and the sessions provided opportunities for participants to respond to the papers. Rapporteurs recorded the discussions.

Each of the sessions were to identify essential competencies and to address what curriculum additions might be necessary to cover the material in sufficient depth, whether this material should be presented in new courses or in modules added to existing courses, whether it should be presented at the undergraduate or graduate level, and to identify potential sources of research funding. The colloquium schedule and a list of the

discussion sessions are included as attachments to this report. Position papers may be downloaded from the colloquium website (http://www.uvm.edu/~dwporter/ncptt/index.htm).

RESULTS AND DISCUSSION

The application of engineering techniques to archaic materials and building systems presents a number of unique challenges that are seldom addressed in university engineering programs, and that are broadly characterized by concurrent commitments to authenticity and historic integrity on the one hand, and public safety on the other.

All, or nearly all, of the position papers emphasized the need for university-level historic preservation engineering (HPE) programs, pointing out that the attention devoted to historic and existing buildings in engineering programs is out of proportion to the construction dollars devoted to their repair and rehabilitation, that there are not enough engineers competent in this area of specialization to meet current needs, and as a consequence much of the work is being done by engineers having too little experience.

Many skills that an engineer will need in doing preservation work are identical or closely related to those required for work with new construction. Steel and concrete design, structural analysis, surveying, graphic communications, foundation design, and engineering geology are a few. But some skills, such as the use of historic analytical tools (for reverse-engineering of existing buildings) and basic familiarity with archaic materials and assemblies, are essential to the practice of HPE and are not taught in university programs.

Ideally, a program in HPE should instill in students a knowledge of historical building systems, a respect for what was previously produced, and an ability to understand what existing systems still have to offer. Curricular additions should include: courses specifically addressing timber, unreinforced masonry, and vernacular materials like adobe; traditional methods of obtaining, converting, assembling, and detailing; deterioration mechanisms; methods of consolidation; levels of safety achievable and; detection of hidden deterioration and determination of current capacity (NDE, NDT).

Courses and modules on the history of engineering, code development, design theory, analytical advances, and period building technology are essential if students are to learn the intent of the original design, whether the components of the system were properly sized and fabricated to meet the design intent, and in order to identify the symptoms of failure.

In terms of identifying the symptoms of failure, deterioration, or distress, the development of nondestructive evaluation (NDE) methods has changed the way engineers approach structural condition assessment projects. A wide range of nondestructive and in situ diagnostics is available to the practicing engineer, and many of the position papers called for the addition of modules and courses devoted to the topic, including: mechanical methods; in situ tests; electrical methods; infrared thermography; ground penetrating radar (GPR); stress wave propagation; nuclear/x-ray; analytical methods and; monitoring.

While many of the skills required in preservation engineering are addressed in the typical civil engineering degree, practitioners working in the field will require:

Enhanced design skills for working with a more extensive set of materials
and assemblies than are currently covered in most programs, including a
knowledge of period analysis techniques for reverse-engineering of
existing systems
Increasingly sophisticated modeling techniques to understand impacts of
stresses
Use of NDE/NDT for detecting deterioration and measuring surviving
capacity

Engineers of many disciplines are responsible for adapting / designing a number of building systems to improve the disaster resistance of existing and historic buildings; these include structural, civil, mechanical, electrical, communications, fire protection, and security systems. Existing curricula in each area of specialty, combined with development of a preservation ethic, would form the core of a disaster-preparedness curriculum.

The stewardship of cultural heritage might be characterized as respect and responsibility for material culture that crosses generational boundaries. Sustainability (meeting the needs of the present without compromising future capacities) pushes our intergenerational responsibility beyond *things*, heritage objects and architecture for example, and requires that we consider the social, environmental and economic impacts of our efforts. Both activities (heritage management / sustainable management) require thinking about resources over long periods of time, and service life expectancy can be said to be a common denominator.

Modules on preservation ethics and regulatory systems could be added to existing Engineering Ethics courses; in addition, preservation ethics and sustainability should constitute a program-wide ethos that is constantly illustrated in the case studies and design workshops that populate the curriculum. Curricular additions should convey:

Concurrent commitments to	public	safety a	and the	heritage v	alue of	f the
resource						

That a sustainable relationship to cultural heritage demands we consider
the social, environmental, and economic impacts of our management
practices
That embodied energy in an existing building has value and the
demolition, transport, and recycling of material components all demand
energy which is not required if the building were to remain in service
That design intent should be set by the original designer or builder

Some resources already exist for providing HPE content to engineering students. In a university context some topics covered by the colloquium (preservation ethics, history of technology) are already taught in university programs outside the school of engineering, and leveraging a full-blown program may require partnering with other programs to provide engineering students access to these courses.

Opportunities for continuing education for practicing professionals exist in the form of courses offered through APTI (Taliesen, Presidio); NCPTT offers its Summer Institute for Architecture and Engineering Training; 2-day workshops on existing building assessment offered by ASCE); workshops offered by the Technical Council on Forensic Engineering to engineering faculty; and hands-on workshops by PTN / TFG workshops.

There are, however, several critical constraints to developing an extended curriculum and resources. Modern universities are funded primarily by undergraduate tuition and research grants, and state contributions are steadily shrinking (often comprising just 10-15% of total funding); only the most elite private schools are significantly funded by endowments. Undergraduate programs must satisfy ABET criteria as well as the needs of a diverse student body with a wide range of career interests. Graduate students in engineering are typically funded either by stipends for thesis-track students (amounting to approximately \$30,000 per year per student) or by their companies for non-thesis track students. Substantial external research money is necessary to achieve critical mass, and faculty are hired to support graduate programs with significant external funding.

As there is no clear answer to the question where research funding to support students would come from, the development of graduate programs in historic preservation engineering is unlikely. Elective tracks and/or minor programs of study would be feasible only if the given engineering school had a partnership with a historic preservation program in liberal arts – without a critical mass of courses the venture would fail. In addition, HPE elective courses would depend on having faculty with the necessary background. Individual HPE modules could be popular, but would require substantial curriculum design effort in collaboration with textbook publishers.

Recommendations were distilled from each of the discussion groups to begin to address these issues. They include:

Recommendation	#1

A conspackag	ortium of firms with HPE expertise could partner with academia by offering a e of: Guest speakers on HPE Tours / field trips related to HPE Summer internships / co-ops related to HPE Funded senior design projects on HPE Adjunct instructors to teach HPE electives Service on advisory boards
	packages would go to select university programs that are willing to commit to g significant HPE content, such as: HPE elective concentration or minor HPE graduate certificate HPE modules in required courses
Recom	mendation #2
Profess	ional societies could increase attractiveness for universities to develop HPE ns by:
	Offering fellowships for graduate study in HPE to individuals attending select programs (with significant HPE content);
	Pressuring funding agencies to increase HPE research grant and educational grant opportunities;
	Partnering with universities to pursue funding for HPE curricular programs Working with companies to offer summer 'HPE graduate internship'
	opportunities to graduate students in select programs; Offering funding for faculty to develop and publish textbooks with HPE modules and content (in collaboration with publishing companies);
	Establishing a mechanism for 'HPE Certification' to recognize universities with significant HPE content.

CONCLUSIONS

While the impediments to development of a graduate program in HPE are significant, colloquium participants have perhaps articulated a way forward. For universities that already offer coursework in historic preservation or cultural resource management in liberal arts programs, interdisciplinary cooperation coupled with the support of industry

and practicing professionals may help engineering programs to achieve the critical mass necessary to develop elective tracks and minor programs in HPE. These, in turn, will help foster the development of curricular modules, faculty skills, and student interest in the topic.

Since the colloquium, engineering faculty at UVM continue to pursue HPE as an area of focus in its engineering programs. These efforts include:

Publication of colloquium proceedings on a university website
(http://www.uvm.edu/~dwporter/ncptt/index.htm). In addition, a special issue of
the APT Bulletin devoted to HPE is planned and will include several of the
position papers presented at the colloquium.
Development of faculty expertise in the area of HPE. This is being pursued on
several fronts. In new Civil Engineering faculty hires, background in NDE, HPE,
or the structural health monitoring of existing construction have been included in
the list of essential competencies. A working relationship has been established
with a group of EU universities offering a program in HPE, and in this context
one UVM faculty has completed a sabbatical at Universidad de Minho, Portugal.
Faculty from the Civil, Mechanical, and Environmental engineering programs,
along with professional partners, continue to participate in research grants related
to HPE, developing in-house expertise and creating opportunities for graduate
student participation.

Next steps include:

- ☐ Encourage formation of an *ad hoc* APT Committee to partner with a university in developing and implementing a pilot HPE-intensive curriculum, based on previous recommendations
- ☐ Seek NSF support for development of this curriculum
- ☐ Capitalize on existing synergies:
 - o associate HPE with sustainability programs at NSF and elsewhere;
 - o leverage substantial funding for NDE and sensors for HPE applications

ACKNOWLEDGMENTS

The Colloquium Committee would like to acknowledge the participation and generous support of the following organizations:

The National Center for Preservation Technology and Training
The Getty Conservation Institute
Shelburne Farms
Shelburne Museum
The University of Vermont Transportation Research Center
The Graduate Program in Historic Preservation at the University of Vermont

The School of Engineering at the University of Vermont